

High Efficiency Ultrasonic Fuel Cleaning

Background

Ultrasonic fuel cleaning technology was originally developed for pressurized water reactors (PWRs) to help eliminate what is currently referred to as crud-induced power shift (CIPS). CIPS occurs when boron-containing crud deposits form on the upper portions of fuel assemblies, resulting in unwanted local flux depressions. Ultrasonic fuel cleaning combined with a CIPS-specific core design allows PWR reactors to operate with higher duty cycles.

The High Efficiency Ultrasonic Fuel Cleaning (HEUFC) system, developed by Dominion Engineering, Inc., departs from the original ultrasonic fuel cleaner design to provide improvements in both cleaning effectiveness and efficiency.

Description

The new HEUFC system consists of a single-chamber cleaning fixture, support frame, filtration system, pump, electrical distribution skid, transducer cabinet and laptop computer. The system can be installed in the spent fuel pool, transfer canal or cask pad, and is controlled from a clean poolside area.

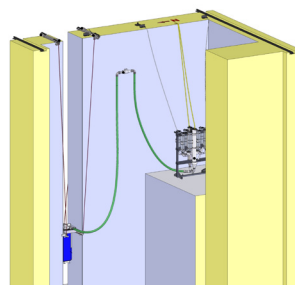
At the start of a fuel cleaning evolution, a fuel assembly is moved above the cleaner with the spent fuel handling tool and then lowered. As the fuel enters the cleaning fixture, the transducers are turned on. The ultrasonic energy generated by the transducers induces cavitation on the fuel rod surfaces, removing crud deposits. A laptop computer is used to control and monitor the cleaning process.

Water enters the top and bottom of the cleaner and exits at the center of the cleaning zone through a suction hose. A pump draws the corrosion products through the suction hose and sends them to the filtration system. The fuel assembly is lowered until the top nozzle nears the top lead-in, and then is raised back up through the cleaning zone to remove additional deposits. The insertion/removal can be repeated if necessary.

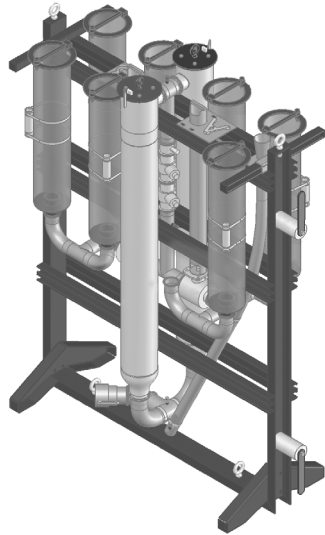
High Efficiency Ultrasonic Fuel Cleaner

A high efficiency ultrasonic fuel cleaner is made up of two “L” shaped transducer banks joined together to make a square assembly that is approximately five feet tall. The cleaner, which is open at the top and bottom, rests in a support frame. Topside wall clamps provide anchor points for the suspension cables from which the cleaner and support frame hang.

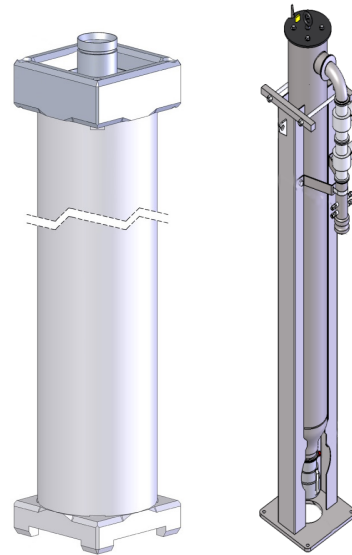
In addition to the cleaning fixture, the support frame can hold a four-face visual system, lights and a bottom nozzle inspection camera for simultaneous cleaning and inspection of fuel assemblies. The control station for the four-face system contains two monitors, one for the bottom nozzle camera and one for the four-face inspection cameras, as well as equipment for recording and post-processing the video data.



Installed fuel cleaner



Option 1: Combination pump/filtration skid



Option 2: AMFM (left) and single pump skid (right)

Box Dimensions (without four-face option)

- Cleaning fixture box (1972 kg): 231 x 147 x 232 cm (L x W x H)
- Electronics box (2570 kg): 303 x 216 x 182 cm (L x W x H)

Filtration and Pumping

Option 1: Combination Pump/Filtration Skid

The skid consists of two redundant filter banks, each with one pump and four filters. Modular pumps can be removed for maintenance and decontamination. The skid includes flow control valves and process instrumentation that measures flow rate, temperature and gamma dose rates.

Option 2: Fuel Assembly Size Metal Filter with Separate Pump Skid

The all metal filter module (AMFM) is built to be handled with the spent fuel tool like a fuel assembly. It is replaced when the maximum allowable differential pressure across the filter is reached, which is projected to be between seven and 10 uses. The AMFM rests in the racks during use and for storage, and the separate single pump skid can be suspended from the spent fuel pool wall.

Box Dimensions (combination pump/filtration skid)

- Filter/pump skid box (2880 kg): 253 x 100 x 234 cm (L x W x H)

Benefits

- Enables higher duty operating by removing boron-containing crud deposits, minimizing CIPS
- Contributes to dose reduction
- Performed without unlatching the fuel assembly from the spent fuel handling tool, decreasing fuel moves required for cleaning
- Approximate two-and-a-half- minute cleaning time per assembly
- Cleaning is performed on a 24-hour continuous-coverage basis and can occur during or after core offload
- Setup, cleaning and operations conducted on separate trips to not interrupt customer's outage schedule
- HEUFC has been analyzed and found to be completely safe for the fuel. Actual use supports this, with no adverse effects on the fuel during subsequent cycles
- The HEUFC system is not a permanent plant fixture and does not constitute a plant modification
- Wetted system components have been electropolished to reduce contamination buildup, minimize crud traps and facilitate decontamination

Experience

HEUFC has been used successfully at multiple plants.

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